BRITISH COLUMBIA
Ministry of Forests

FOREST RENEWAL BC

December 1998

# OAF1 PROJECT REPORT 2

## Ground-Based Survey Method

This is the second in a series of reports on the progress of the OAF1 project. OAF1 is the Type 1 Operational Adjustment Factor used by the BC Ministry of Forests growth and yield model, TIPSY (Table Interpolation Program for Stand Yields). Background on OAF1 is available in the first report in this series: **An Overview of Stocking Gaps and OAF1 Estimates for TIPSY**. This second report provides detailed instructions for conducting the new ground-based silviculture survey used for estimating OAF1. Subsequent reports in this series will describe other aspects of the OAF1 project.

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### Background

**Most TIPSY users assume an OAF1 value of 15%. Until now, there has been no survey method for checking this assumed value.**

The OAF1 Project was initiated in 1996 with Forest Renewal BC funding in order to develop methods of estimating OAF1 for TIPSY. OAF1 is a TIPSY input parameter that reduces yield estimates to account for small stocking gaps in the stand (Mitchell and Grout 1995). For a more complete discussion of OAF1, see Report No. 1 in this series. A recent review of assumptions used in timber supply analyses found that most analyses assume an OAF1 of 15% (Winter 1997). Until now there has been no method for checking this assumed value through a ground-based survey of stocking gaps in individual stands.

### Survey Objective

The new ground-based survey estimates the OAF1 input value for a single polygon TIPSY run. The OAF1estimate will adjust the TIPSY volume/ha prediction at harvest by the amount required to account for the small stocking gaps in the stand. This OAF1 value will provide the appropriate

**The objective of the survey is to produce a more accurate estimate of the OAF1 input value for a single polygon TIPSY run.**

reduction to merchantable volume/ha at the time of the culmination of mean annual increment.

This survey may be used to achieve other objectives, but it is specifically designed to estimate OAF1. Other survey designs may satisfy other objectives more efficiently.

## Suitable Stands

**Many 3-6 m tall stands are candidates for the OAF1 survey.**

The OAF1 survey is designed for young, even-aged stands in which ingress is completed. Many stands with an average height of 3-6 m are candidates for this survey.

## Species Composition

The survey was developed for pure species stands of Cw, Fd, Hw, Pl, Ss, or Sx. The accuracy of the survey in mixed species stands is not known.

## Fill In

The survey assumes that tree establishment is completed and stable. The survey will not provide an accurate OAF1 if the number of stocking gaps changes as a result of ingress or new pockets of mortality.

## Stocking Gap Shape

The survey is designed to detect small stocking gaps distributed throughout the block. Another method may be more efficient for surveying stocking gaps with other shapes (for example, long windrows or a single slash pile).

## Density

The survey is designed for the range of stand density that can be input to TIPSY version 1.3: 331/ha to10,000/ha for naturally regenerated stands; 331/ha to 4,000/ha for planted stands.

## Integration with Other Surveys

**OAF1 survey data can be collected during some standard silviculture surveys.**

OAF1 survey data can be collected during many free-growing and pre-stand-tending surveys. Alternatively, a block can be surveyed exclusively for the purpose of collecting OAF1 data. The OAF1 survey is designed to be simple, ground-based, and compatible with basic silviculture survey procedures.

The OAF1 value computed from this survey is appropriate for TIPSY version 1.3

## TIPSY Version

The OAF1 value computed from this survey is appropriate for TIPSY version 1.3. It may not be appropriate for subsequent versions of TIPSY if the underlying yield tables are changed. This OAF1 value may not be appropriate for other yield models.

Conditions that limit the reliability of the OAF1 survey include the wide variety of initial stand structures, stand development patterns, and site conditions.

## Limitations

The wide natural variation in initial stand structures, stand development patterns, and site conditions limits the reliability of the OAF1 survey. The survey was developed for pure species stands. We do not know how reliable the survey is when stands are not pure. Ingress after the survey may fill in stocking gaps and reduce the yield loss. Alternatively, mortality may increase losses by creating more stocking gaps after the survey.

Surveyors will encounter conditions in which they are not sure whether to tally a tree. We do not know the exact specifications of an acceptable tree.

Small stocking gaps are only one of the many reasons why the yields achieved under operational conditions may differ from yields predicted by models like TIPSY. Although an improved estimate of OAF1 will account for the effect of stocking gaps on yields, it does not account for many other factors that can cause achieved yields to fall below TIPSY-predicted yields. These factors include:

- biotic and abiotic damage agents such as insects, disease, wind, and snow;
- decay, waste, and breakage at harvest; and
- the effect of species mixes.

OAF1 accounts for the effect on yield of small stocking gaps in the stand, but it may be necessary to make additional reductions to TIPSY predictions to account for the effect of other factors such as insects, disease, damage, decay, waste, breakage, species mix, and so on.

# Preparing and Conducting an OAF1 Survey

## 1. Delineate strata.

Before conducting an OAF1 survey in an opening, you need to delineate strata. A stratum is the unit of land to which the TIPSY yield prediction will apply. When running TIPSY to support prescription writing, the stratum is often the Standards Unit. In other cases, the stratum may be the forest-cover polygon or treatment area.

Before you begin the survey, you will need a clear description and a map of what is, and is not, part of the stratum. Specifically, you need to decide how you will handle roads, landings, natural non-productive cover, man-made non-productive cover, and non-commercial cover. You have two options.

**OPTION 1:** Include these areas in the OAF1 survey. This will result in a larger OAF1 value, and you will need to apply the resulting TIPSY volume/ha predictions to gross area.

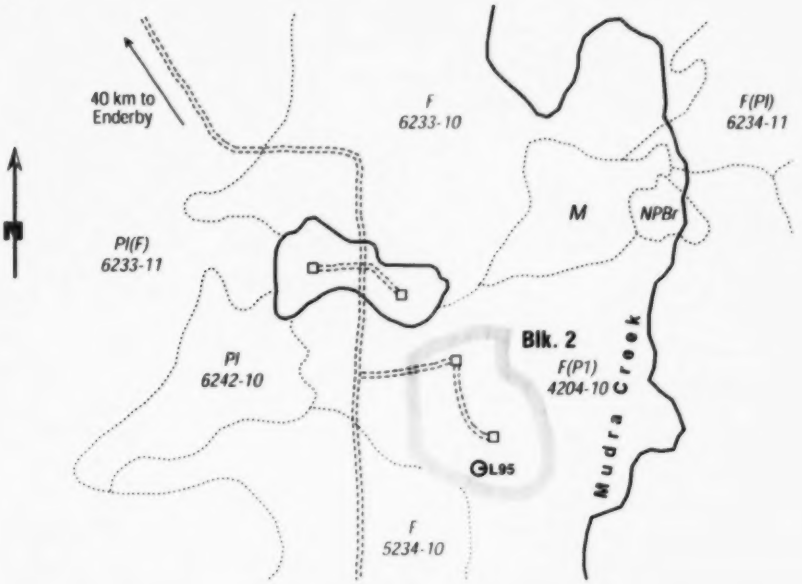
**OPTION 2:** Exclude these areas from the OAF1 survey. This will result in a smaller OAF1 value, and you will need to apply the resulting TIPSY volume/ha predictions to net area. Timber yield on the excluded hectares will be zero.

**Before you start the survey, you must clearly identify the area of land to which the TIPSY results will apply.**

Generally, you should "type-out" (map as non-productive) major roads and landings and large areas of non-productive and non-commercial cover. Include the remaining smaller patches of non-productive and non-commercial cover in the OAF1 survey. Apply the resulting TIPSY volume/ha predictions to the area that excludes the mapped non-productive areas. Assume the timber yield from the mapped non-productive is zero (Figure 1).

**Figure 1**

**An opening with one productive stratum and one non-productive stratum. OAF1 survey plots will not be located in the non-productive stratum. The survey estimate of OAF1 and the associated TIPSY volume/ha predictions apply to the productive area only. Yield from the non-productive stratum is assumed to be zero.**




| NET AREA TO BE REFORESTED | | | | | | NON-PRODUCTIVE AREA | | | | | OTHER AREA | | | | GROSS AREA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | | | | | TOTAL | NP NAT | NP RDS | NP LDG | | TOTAL | Tbr | | | TOTAL | |
| 20.0 | | | | | 20.0 | | 0.6 | 1.0 | | 1.6 | | | | | 21.6 |

Use 100 plots per stratum.

## 2. Select number of plots.

The best information currently available suggests that 100 survey plots per stratum will provide an accurate estimate of OAF1.

## 3. Position plots.

Within each stratum, position the OAF1 survey plots to achieve uniform coverage of the entire stratum (Figure 2). A systematic plot lay out will achieve uniform coverage. If you are collecting OAF1 data in conjunction with a standard silviculture survey, you will probably need to:

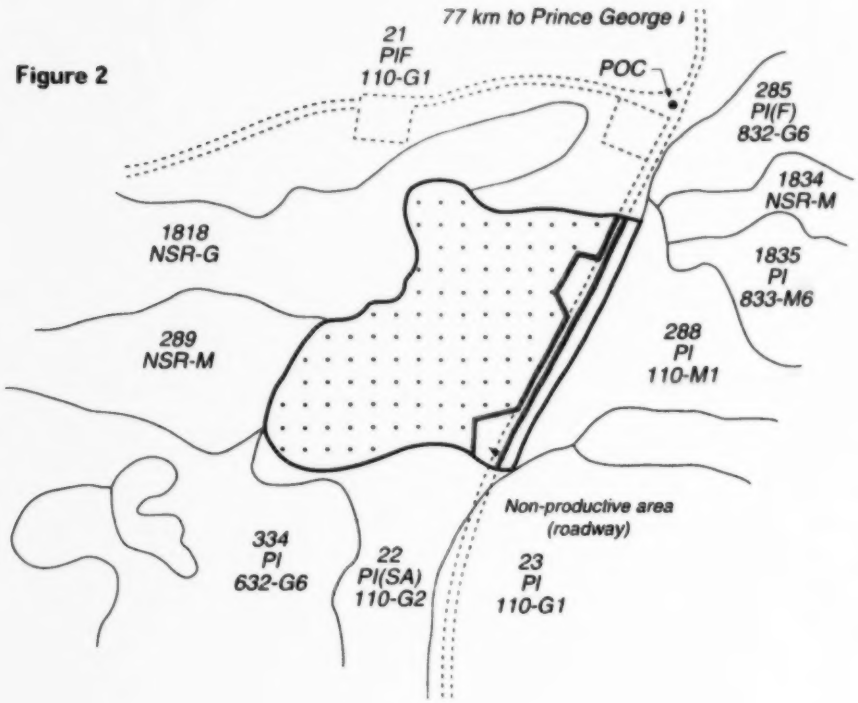
- collect OAF1 data at each standard silviculture survey plot.
- add OAF1 survey plots along existing survey lines.

To establish 100 plots on a square grid, you can calculate the required distance between survey lines and plots from the stratum area:

Distance between lines and plots (m) = $\sqrt{(\text{area})(100)}$

where area = stratum area in hectares.

**Figure 2**




One possible plot layout for collecting OAF1 survey data.

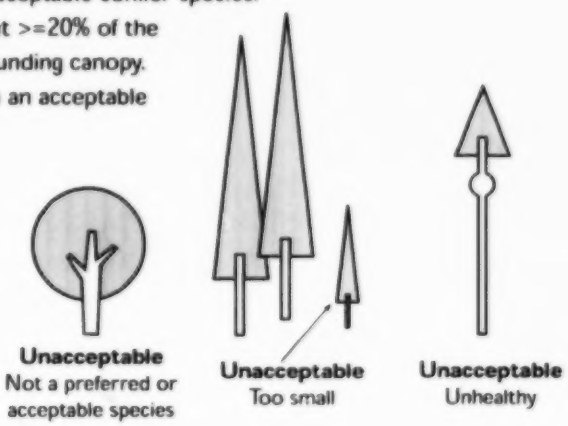
## 4. Determine criteria for acceptable trees

Before beginning the survey, you will need to establish criteria for deciding which trees are acceptable for the purposes of the OAF1 survey. Determining whether a tree is acceptable is a simple decision when the plot contains either no trees or a very good tree. Difficulties arise when the tree is very small, in poor condition, or an unacceptable species. Conceptually, you want to count as a tree only a healthy commercial species that will survive and grow. Common criterea are:

- count only preferred and acceptable conifer species.
- count only trees with height >=20% of the average height of the surrounding canopy.
- count only trees that are in an acceptable condition (Figure 3).

Examples of trees that are not acceptable for the purpose of the OAF1 survey.

**Figure 3**




## 5. Select appropriate critical distance.

A plot has landed in a stocking gap when there is no acceptable tree within a critical distance from plot center (Figure 4). This critical distance depends on the species.

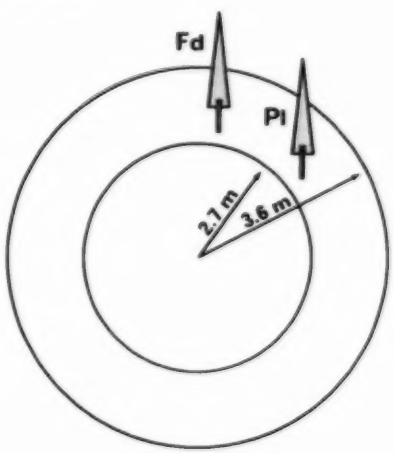
For Cw, Fd, Hw, and Ss, the critical distance is 3.6 m.
For Pl and Sx, the critical distance is 2.7 m.

At present, we do not know the critical distance for other species. However, TIPSY species substitutions (Mitchell and Grout 1995) suggest some approximate critical distances:

3.6 m for Ba, Bg, Hm, Lw, Pw, Py, Yc
2.7 m for Bl, La, Lt, Pa, Pf, Pj, Sb, Se, Sw

Example in which Pl is not within the critical distance, but Fd is.

**Figure 4**



## 6. Count acceptable trees.

At plot center, determine whether or not there is an OAF1 acceptable tree within the critical distance.

At each plot center, confirm that the plot is in the stratum (and not in a typed-out area). If the plot has fallen in a location that is not part of the stratum, do not collect OAF1 data. Drop the plot and do not use it in subsequent complilations.

If the plot lands in the stratum, determine whether or not there is an acceptable tree within the critical distance from plot center.

Record 1 (one) on the field sheet if there are one or more acceptable trees within the critical distance. Record 0 (zero) if there are no acceptable trees within the critical distance (Figure 5).

Example of OAF1 survey field data.

Opening: 82056-39
Stratum: A

| Plot # | OAF 1 acceptable Tally |
|---|---|
| 1 | 1 |
| 2 | 1 |
| 3 | 0 |
| 4 | 0 |
| 5 | 1 |
| 6 | 1 |
| 7 | 1 |

**Figure 5**

## 7. Collect additional data.

The surveyor must also determine total trees/ha and site index.

In addition to counting stocking gaps, the surveyor must collect the data required to estimate total trees/ha and site index. In low-density stands, an accurate estimate of total trees/ha is particularly important.

If you plan to use the OAF1 survey data to assess treatment options, you may want to collect additional observations on the approximate size, location of, and treatment options for the stocking gaps.

## 8. Compile data.

After completing the survey, calculate the following for the stratum:

- percent empty plots (PEP)
  PEP = 100% (number of plots coded 0/total number of plots)
- site index
- current total trees/ha
- stand origin
- critical distance most frequently used in the survey (2.7 m or 3.6 m)
- dominant species (Cw, Fd, Hw, Pl, Ss, or Sx)

The next stage of the compilation requires a two-step procedure.
Step 1. Find the Z value in Table 1.
Step 2. Transfer the Z value to Table 2 to obtain the OAF1 estimate.

## 9. Find Z value in Table 1.

In Table 1, find the section that corresponds to the stand origin and the critical distance most frequently used in the survey. For stands of natural origin, read down the first column to the row that corresponds to the total trees/ha. The body of the table contains PEP values. Read across this row to the number that is closest to the calculated Percent Empty Plots (PEP) value. Read up the column into the table header to obtain the Z value. Interpolate between table values if necessary.

For stands of natural origin, find the Z value given by total trees/ha and PEP. For example, in a naturally regenerated stand in which the critical distance for most species is 3.6 m, the density is 800 trees/ha, and the PEP is 9%, the Z value is 5.

**Figure 6 (Table 1 A)**

**Section A** Origin: Natural
Critical Distance: 3.6 m

| Trees per hectare | Z value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | Percent Empty Plots (PEP) | | | | | | |
| | 331 | 26 | 31 | 36 | 41 | 46 | 51 | 56 |
| | 400 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | 500 | 13 | 18 | 23 | 28 | 33 | 38 | 43 |
| | 600 | 9 | 14 | 19 | 24 | 29 | 34 | 39 |
| | 700 | 6 | 11 | 16 | 21 | 26 | 31 | 36 |
| | 800 | 4 | 9 | 14 | 19 | 24 | 29 | 34 |
| | 900 | 3 | 8 | 13 | 18 | 23 | 28 | 33 |
| | 1000 | 2 | 7 | 12 | 17 | 22 | 27 | 32 |
| | 1200 | 0 | 6 | 11 | 16 | 21 | 26 | 31 |
| | 1500 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 2000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 3000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 4000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |

For stands of planted origin, read down Table 1, Section C to the row that corresponds to the PEP value. Record the associated Z value. Interpolate between table values if necessary.

In stands of planted origin, find the Z value given by PEP. For example, in a planted stand with a PEP of 8.5%, the Z value is 5.

**Section C** Origin: Planted
Critical Distance: 2.7 m and 3.6 m

| PEP | Z value |
|---|---|
| 3.5 | 0 |
| 8.5 | 5 |
| 13.5 | 10 |
| 18.5 | 15 |
| 23.5 | 20 |
| 28.5 | 25 |
| 33.5 | 30 |

**Figure 7 (Table 1 C)**

## 10. Look up OAF1 in Table 2.

In Table 2, find the section that corresponds to the stand origin and dominant species. Read across the table header to the column that corresponds to the Z value. Read down this column to the number that occupies the same row as the site index. The number in the body of the table is the survey estimate of OAF1. Interpolate between table values if necessary.

**Table 2 uses the Z value and the site index to obtain the survey estimate of OAF1. For example, a naturally regenerated Fdc stand with Z value = 10 and site index = 30 will have an OAF1 of 7%.**

**Figure 8 (Table 2)**

**Spp: Fdc** **Origin: Natural**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | OAF 1 | | | | | | |
| 20 | 0% | 4% | 8% | 12% | 17% | 21% | 25% |
| 25 | 0% | 3% | 8% | 12% | 16% | 20% | 24% |
| 30 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| 35 | 0% | 3% | 7% | 11% | 15% | 18% | 22% |
| 40 | 0% | 3% | 7% | 10% | 14% | 18% | 21% |

If TIPSY version 2.1 is used, convert the OAF1 value to a multiplier. For example, convert 5% to 0.95; 10% to 0.90; 15% to 0.85, etc.

## 11. Estimate establishment density.

To most closely mimic the effect of stocking gaps on yield, TIPSY requires both an estimate of OAF1 and an adjusted initial density. In Table 3, use the Z value and current total trees/ha to estimate density at establishment.

**Table 3 uses the Z value and the current total trees/ha to estimate an initial density for the TIPSY run. For example, a stand with a Z value = 10 and total trees/ha = 2000, will have a TIPSY establishment density of 2309/ha.**

**Figure 9 (Table 3)**

| Z value | Current #/ha 500 | 1000 | 2000 | 3000 | 4000 | 5000 | 10000 |
|---|---|---|---|---|---|---|---|
| | TIPSY Establishment density (#/ha) | | | | | | |
| 0 | 514 | 1035 | 2077 | 3119 | 4161 | 5203 | 10413 |
| 5 | 541 | 1090 | 2187 | 3284 | 4380 | 5477 | 10961 |
| 10 | 572 | 1151 | 2309 | 3466 | 4624 | 5782 | 11571 |
| 15 | 606 | 1219 | 2445 | 3671 | 4897 | 6122 | 12252 |
| 20 | 644 | 1296 | 2598 | 3901 | 5203 | 6506 | 13018 |
| 25 | 688 | 1382 | 2772 | 4161 | 5550 | 6940 | 13886 |
| 30 | 737 | 1482 | 2970 | 4459 | 5947 | 7436 | 14879 |

# Example

**This example illustrates the process of collecting OAF1 data, compiling it, and initiating a TIPSY run.**

The following example illustrates the OAF1 survey process.

### SURVEY OBJECTIVE

For a Stand Management Prescription, the surveyor needed to determine the appropriate OAF1 value for a TIPSY run for a stratum.

### TIPSY VERSION

The surveyor confirmed that the version of TIPSY being used was appropriate for use with the OAF1 tables.

### STAND SUITABILITY

Because the stand was 4 m tall and pure lodgepole pine, it appeared suitable for an OAF1 survey.

### STRATIFICATION

The opening contained a 25-ha stratum of productive area and a 1-ha non-productive stratum consisting of one swamp and one major road. The surveyor wanted the TIPSY volume/ha predictions to apply only to the 25-ha stratum. Therefore, the surveyor did not establish OAF1 plots in the non-productive stratum.

### NUMBER OF PLOTS

The survey consisted of 100 plots.

### PLOT LAYOUT

The surveyor chose a square survey grid to achieve uniform coverage of the entire stratum area. The stratum size (25 ha) suggested a distance between lines and plots of 50 m ($\sqrt{(25)(100)}$ = 50 m).

### CRITERIA FOR ACCEPTABLE TREES

The surveyor established the following criteria for acceptable trees: more than 20% of the height of the surrounding canopy, and preferred or acceptable conifer species in good condition.

### CRITICAL DISTANCE

Because the stand was pure Pl, the appropriate critical distance was 2.7 m.

### PLOT DATA

At each plot center, the surveyor confirmed that the plot was in the stratum. If not, the surveyor dropped the plot and did not use it in subsequent compilations. If the plot was in the stratum, the surveyor determined if there was an acceptable tree within the critical distance from plot center. The surveyor recorded 1 for an acceptable tree in the plot and 0 for no acceptable trees in the plot.

## ADDITIONAL DATA

The surveyor collected data to estimate site index and total trees/ha.

## COMPILATION

From the survey data, the surveyor computed the following

- Percent of plots without acceptable trees (PEP) = 8%
- Site index = 20 m
- Current total trees = 1500/ha
- Critical distance most frequently used in survey: 2.7 m
- Dominant species: Pl
- Stand origin: natural

## TABLE 1 – Z VALUE

Because the stand was of natural origin and most of the plots used a critical distance of 2.7m, the surveyor selected Section B of Table 1. Given total trees = 1500/ha and PEP = 8%, the Z value was 5.

## TABLE 2 – OAF1 VALUE

In Table 2, the surveyor identified the section for natural origin Pl. With site index = 20 and Z value = 5, the estimated OAF1 was 4%.

## ESTABLISHMENT DENSITY

Given the Z value (5) and total trees (1500/ha), the surveyor interpolated within Table 3 to obtain an appropriate initial density for the TIPSY run.

Establishment density = 1090 + 0.5 (2187–1090) = 1639/ha

## TIPSY RUN

The input specifications for the TIPSY run were:

| | |
|---|---|
| Species: | Pl |
| Origin: | Natural |
| Site index: | 20 m |
| Initial density: | 1639/ha |
| OAF1: | 4% |
| OAF2: | 10% |

## OAF1 Project Team

The achievements of the OAF1 Project have been accomplished by the efforts of staff in the Ministry of Forests Forest Practices Branch and Research Branch, and the consulting firms of Beacon Hill Communications Group Inc., Laing and McCulloch Forest Management Services Ltd., Timberline Forest Inventory Consultants Ltd., and J. S. Thrower and Associates Ltd.

## Where to Get More Information

To obtain additional copies of this report or to obtain copies of the other reports in this series, follow the instructions on the back of this document.
For more information, contact:

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## Literature Cited

Mitchell, K.J. and S.E. Grout. 1995. WinTIPSY user's guide for producing managed stand yield tables with WinTIPSY version 1.3 under Microsoft Windows. B.C. Ministry of Forests, Research Branch, Victoria, B.C.

Winter, R. 1997. Assumptions included in timber supply analyses: Timber Supply Areas and Tree Farm Licences. B.C. Ministry of Forests, Forest Practices Branch, Victoria, B.C.

# Table 1. Table of Z Values

**Section A** Origin: Natural
Critical Distance: 3.6 m

| Trees per hectare | Z value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | Percent Empty Plots (PEP) | | | | | |
| | 331 | 26 | 31 | 36 | 41 | 46 | 5. | 56 |
| | 400 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| | 500 | 13 | 18 | 23 | 28 | 33 | 38 | 43 |
| | 600 | 9 | 14 | 19 | 24 | 29 | 34 | 39 |
| | 700 | 6 | 11 | 16 | 21 | 26 | 31 | 36 |
| | 800 | 4 | 9 | 14 | 19 | 24 | 29 | 34 |
| | 900 | 3 | 8 | 13 | 18 | 23 | 28 | 33 |
| | 1000 | 2 | 7 | 12 | 17 | 22 | 27 | 32 |
| | 1200 | 0 | 6 | 11 | 16 | 21 | 26 | 31 |
| | 1500 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 2000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 3000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 4000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 5000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| | 10000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |

# Table 1. Table of Z Values

**Section B** Origin: Natural
Critical Distance: 2.7 m

| Z value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | Percent Empty Plots (PEP) | | | | | |
| 331 | 47 | 52 | 57 | 62 | 67 | 72 | 77 |
| 400 | 40 | 45 | 50 | 55 | 60 | 65 | 70 |
| 500 | 32 | 37 | 42 | 47 | 52 | 5 | 62 |
| 600 | 25 | 30 | 35 | 40 | 45 | 50 | 55 |
| 700 | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| 800 | 16 | 21 | 26 | 31 | 36 | 41 | 46 |
| 900 | 13 | 18 | 23 | 28 | 33 | 38 | 43 |
| 1000 | 10 | 15 | 20 | 25 | 30 | 35 | 40 |
| 1200 | 6 | 11. | 16 | 21 | 26 | 31 | 36 |
| 1500 | 3 | 8. | 13 | 18 | 23 | 28 | 33 |
| 2000 | 1 | 6 | 11 | 16 | 21 | 26 | 31 |
| 3000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| 4000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| 5000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
| 10000 | 0 | 5 | 10 | 15 | 20 | 25 | 30 |

Trees per hectare

**Section C** Origin: Planted
Critical Distance: 2.7 m and 3.6 m

| PEP | Z value |
|---|---|
| 3.5 | 0 |
| 8.5 | 5 |
| 13.5 | 10 |
| 18.5 | 15 |
| 23.5 | 20 |
| 28.5 | 25 |
| 33.5 | 30 |

# Table 2. Estimate of OAF 1

**Spp: Cw** **Origin: Natural**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 15 | 0% | 3% | 7% | 10% | 15% | 18% | 22% |
| | 20 | 0% | 3% | 7% | 10% | 14% | 18% | 22% |
| | 25 | 0% | 2% | 6% | 10% | 13% | 17% | 21% |
| | 30 | 0% | 2% | 5% | 9% | 12% | 16% | 19% |
| | 35 | 0% | 2% | 5% | 8% | 11% | 15% | 18% |

**Spp: Fdc** **Origin: Natural**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 20 | 0% | 4% | 8% | 12% | 17% | 21% | 25% |
| | 25 | 0% | 3% | 8% | 12% | 16% | 20% | 24% |
| | 30 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| | 35 | 0% | 3% | 7% | 11% | 15% | 18% | 22% |
| | 40 | 0% | 3% | 7% | 10% | 14% | 18% | 21% |

**Spp: Fdi** **Origin: Natural**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 12 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| | 16 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| | 20 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| | 24 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |

**Spp: Hw** **Origin: Natural**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 15 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| | 20 | 0% | 4% | 8% | 12% | 16% | 19% | 23% |
| | 25 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| | 30 | 0% | 3% | 7% | 11% | 15% | 18% | 22% |
| | 35 | 0% | 3% | 7% | 10% | 14% | 18% | 21% |

# Table 2. Estimate of OAF 1

**Spp: Pl** **Origin: Natural**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 12 | 0% | 4% | 8% | 12% | 17% | 21% | 25% |
| 16 | 0% | 4% | 8% | 13% | 17% | 22% | 26% |
| 20 | 0% | 4% | 9% | 13% | 18% | 22% | 26% |
| 24 | 0% | 4% | 9% | 13% | 18% | 23% | 27% |

**Spp: Ss** **Origin: Natural**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 20 | 0% | 3% | 7% | 12% | 16% | 20% | 24% |
| 25 | 0% | 3% | 7% | 11% | 16% | 20% | 24% |
| 30 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| 35 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| 40 | 0% | 3% | 7% | 10% | 15% | 18% | 22% |

**Spp: Sw** **Origin: Natural**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 12 | 0% | 4% | 8% | 13% | 17% | 21% | 26% |
| 16 | 0% | 4% | 8% | 13% | 17% | 21% | 26% |
| 20 | 0% | 4% | 8% | 13% | 17% | 21% | 26% |
| 24 | 0% | 4% | 8% | 13% | 17% | 22% | 26% |

**Spp: Cw** **Origin: Planted**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 15 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| 20 | 0% | 3% | 7% | 10% | 14% | 18% | 21% |
| 25 | 0% | 3% | 6% | 10% | 13% | 16% | 20% |
| 30 | 0% | 2% | 6% | 9% | 12% | 15% | 18% |
| 35 | 0% | 2% | 5% | 8% | 11% | 14% | 17% |

# Table 2. Estimate of OAF 1

**Spp: Fdc** **Origin: Planted**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 20 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| 25 | 0% | 4% | 8% | 12% | 15% | 19% | 23% |
| 30 | 0% | 3% | 7% | 11% | 15% | 19% | 22% |
| 35 | 0% | 3% | 7% | 11% | 14% | 18% | 22% |
| 40 | 0% | 3% | 7% | 10% | 14% | 17% | 21% |

**Spp: Fdi** **Origin: Planted**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 12 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| 16 | 0% | 4% | 8% | 12% | 16% | 20% | 24% |
| 20 | 0% | 4% | 8% | 11% | 15% | 19% | 23% |
| 24 | 0% | 4% | 7% | 11% | 15% | 19% | 23% |

**Spp: Hw** **Origin: Planted**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 15 | 0% | 4% | 8% | 11% | 15% | 19% | 23% |
| 20 | 0% | 3% | 7% | 11% | 15% | 19% | 22% |
| 25 | 0% | 3% | 7% | 11% | 14% | 18% | 22% |
| 30 | 0% | 3% | 7% | 10% | 14% | 17% | 21% |
| 35 | 0% | 3% | 7% | 10% | 13% | 17% | 20% |

**Spp: Pl** **Origin: Planted**

| Site Index (m) | Z Value 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|
| | | | | OAF 1 | | | |
| 12 | 0% | 4% | 9% | 13% | 18% | 22% | 27% |
| 16 | 0% | 4% | 9% | 13% | 18% | 22% | 27% |
| 20 | 0% | 4% | 9% | 13% | 18% | 22% | 26% |
| 24 | 0% | 4% | 9% | 13% | 17% | 22% | 26% |

# Table 2. Estimate of OAF 1

**Spp: Ss** **Origin: Planted**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 20 | 0% | 4% | 8% | 11% | 15% | 19% | 23% |
| | 25 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| | 30 | 0% | 3% | 7% | 11% | 15% | 19% | 23% |
| | 35 | 0% | 3% | 7% | 11% | 14% | 18% | 22% |
| | 40 | 0% | 3% | 7% | 10% | 14% | 18% | 21% |

**Spp: Sw** **Origin: Planted**

| Site Index (m) | Z Value | 0 | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|---|---|
| | | | | | OAF 1 | | | |
| | 12 | 0% | 4% | 8% | 12% | 17% | 21% | 25% |
| | 16 | 0% | 4% | 8% | 13% | 17% | 21% | 25% |
| | 20 | 0% | 4% | 8% | 13% | 17% | 21% | 25% |
| | 24 | 0% | 4% | 8% | 13% | 17% | 21% | 26% |

# Table 3. Establishment density for TIPSY run

| Current #/ha | 500 | 1000 | 2000 | 3000 | 4000 | 5000 | 10000 |
|---|---|---|---|---|---|---|---|
| | TIPSY Establishment density (#/ha) | | | | | | |
| 0 | 514 | 1035 | 2077 | 3119 | 4161 | 5203 | 10413 |
| 5 | 541 | 1090 | 2187 | 3284 | 4380 | 5477 | 10961 |
| 10 | 572 | 1151 | 2309 | 3466 | 4624 | 5782 | 11571 |
| 15 | 606 | 1219 | 2445 | 3671 | 4897 | 6122 | 12252 |
| 20 | 644 | 1296 | 2598 | 3901 | 5203 | 6506 | 13018 |
| 25 | 688 | 1382 | 2772 | 4161 | 5550 | 6940 | 13886 |
| 30 | 737 | 1482 | 2970 | 4459 | 5947 | 7436 | 14879 |

Z value

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